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Title: Applications of Nuclear Criticality Safety at Los Alamos National Lab

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# Applications of Nuclear Criticality Safety at Los Alamos National Lab

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National Nuclear Security Administration
Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

# Agenda

- Brief Recap
- Los Alamos National Laboratory
- NCS at LANL
- Final Thoughts

# Brief Recap

# Nuclear Criticality Safety

**The art and science of preventing criticality accidents and ensuring that anyone that could be exposed to one makes it home alive at the end of the day.**

- **Criticality Accident – Release of energy as a result of accidentally producing a self-sustaining or divergent fission chain reaction.**
  - i.e. An unintended nuclear reactor, usually without shielding, coolant, and control
  - Can kill or injure people and damage processing equipment

# Typical Practice

- **Operations proposes a new process or a change to an existing process**
- **Criticality Safety staff analyze the system**
  - Ensure the entire process remains subcritical under all normal and credible abnormal conditions.
  - Process designs should incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. (Double Contingency Principle)
- **Criticality Safety staff work with Operations and Engineering staff to develop controls on the process**

# Controls

- **Controls are developed to limit process parameters important to criticality safety**
  - Mass
  - Absorption
  - Geometry
  - Interaction
  - Concentration/Density
  - Moderation
  - Enrichment
  - Reflection
  - Volume
- **Hierarchy of Controls:**
  - Natural Process Constraints
  - Passive Engineered Controls
  - Active Engineered Controls
  - Administrative Controls
- **Controls must be easy to implement or people will find work-arounds**

# Los Alamos National Laboratory

# LANL Overview

- **New Contractor: TRIAD National Security, LLC**
  - Battelle Memorial Institute, The Texas A&M University System, and the University of California
- **~40 square miles**
- **Employs ~12,000 people**
  - Looking to hire ~1000 people per year for the next few years
- **$2.55 billion annual budget**
- **Projects spanning every discipline, across dozens of facilities**
- **Most funding comes from weapons program**
- **Other major programs:**
  - Nonproliferation
  - Nanotechnology
  - Supercomputing
  - Neutron sciences
  - Isotope Production

# NCS Applicability

- **NCS supports all "facilities or activities that may exceed, under normal or credible abnormal conditions, a significant quantity threshold."**

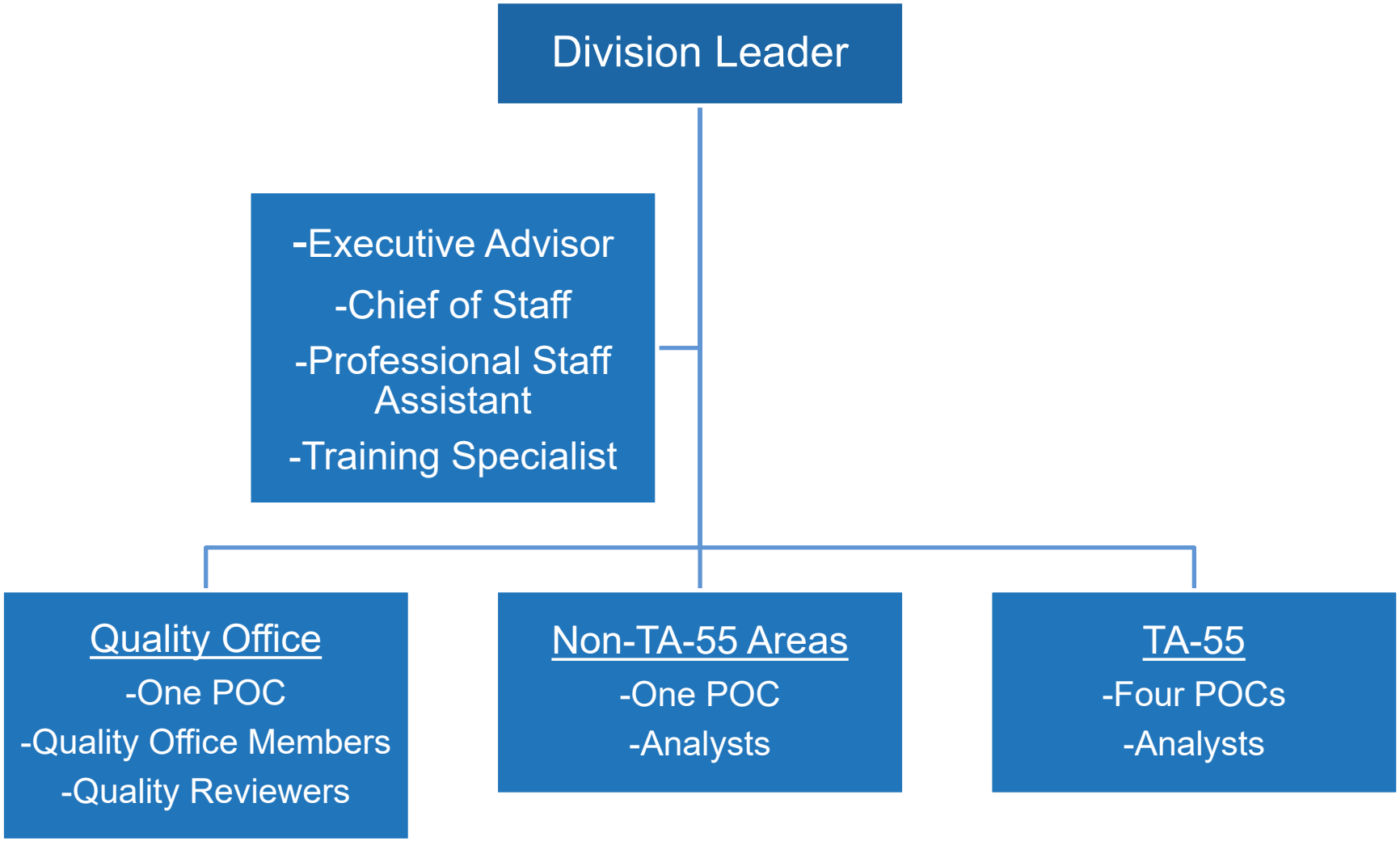
| Material | Mass (g) |
|---|---|
| 239Pu | 450 |
| 235U | 700 |
| 233U | 500 |
| Combinations of 239Pu/235U/233U | 450 |
| Pu ≥ 75% 238Pu | 5000 |
| Pu ≥ 75% 242Pu | 5000 |
| Special Actinides | ANSI/ANS-8.15 Single Parameter Limits and/or consult with NCSD |

# Major NCS Customers

- Plutonium Facility (PF-4)
- Chemistry and Metallurgy Research Facility (CMR)
- Nevada National Security Site (NNSS)
- Science and Technology Operations (STO)
- Environmental and Waste Management Operations (EWMO)

# NCS at LANL
# Organization and Responsibilities

# NCSD Organization



# Flow of NCS Requirements

**High-Level Legal Requirement: 10 CFR 830, Section 830.204**

- *Ensures that operations with fissionable material remain subcritical under all normal and credible abnormal conditions*
- *Identifies applicable nuclear criticality safety standards*
- *Describes how the program meets applicable nuclear criticality safety standards*

**Required by DOE Order 420.1C**

**Captured in the LANL NCS Program Document, SD-130**

*(approved by DOE)*

**Implemented for Each Facility (AP-522)**

**Criticality Safety Evaluation Documents**

# Evaluating Operations

- **Operations submits an Operation Requirements Document (ORD) describing new process or change to a process**
- **NCS accepts the work**
- **Evaluation team is formed**
  - Operations Responsible Supervisor, 2 NCS analysts, Operations and Engineering staff, other experts as needed.
- **Walk-down the process**
- **Evaluate and develop controls**
- **Operations Review**
- **NCS Independent Review**
- **NCS Quality Review**
- **Implement controls**
  - Criticality Safety Posting
  - Procedures

# Reviewing Operations and Procedures

- **Observe day-to-day work**
  - Ensure NCS controls are implemented
- **Fissile Material Operation Reviews (FMORs)**
  - Performed annually for every operation
  - Ensure process still aligns with evaluation
    - Verify process and equipment are as described, assumptions made in evaluation are still accurate, Operations understands the control set.
- **Procedure Reviews**
  - Any procedure that might impact an NCS parameter has to be reviewed and approved by NCS.

# Responding to Potential Process Deviations and Emergencies

- People make mistakes.
- When mistakes are made, and controls are potentially broken, we respond
- Usually, Operations notices potential deviation, stops work, and calls NCS
- Sometimes trivial; sometimes serious
- Facility is usually overly conservative in calling us, which we appreciate
- Fact finding is held and recovery plan is made

- Train to be prepared to respond to potential Criticality Accident
  - Trainings and annual drills

# Potential Process Deviations

- **Can be as trivial as a typo**
- **Can be as serious as an over-massed location**
  - 2011 photo-op example
- **Most called out of an abundance of caution**
- **Vast majority are very safe and nowhere near a critical configuration due to conservatism built into everything we do**

# Training and Education

- **Provide NCS training to Operations personnel**
  - Train:
    - Fissile Material Handlers
    - Operations Responsible Supervisors
    - Craft workers
    - Managers

- **Teach DOE NCS courses**
  - DOE NCSP Hands-on Training course is required to become an NCS Engineer at any DOE site, and we get to help shape it
- **Teach at universities across the country**
  - Pipeline courses at Texas A&M University, University of California Berkeley, Idaho State University, and New Mexico State University
  - Others under consideration
- **Receive training on NCS and other facility/operations topics**

# Standards, Conferences, Collaboration

- **Contribute to ANSI/ANS 8 Series standards**
- **Attend national and international conferences**
  - ANS, ICNC, etc.
- **Collaborate with foreign allies**
  - Joint Working Group (JOWOG) 30 allows us to collaborate with our British counterparts
  - Regular calls and annual meetings

# Final Thoughts

# Final Thoughts

- **Subject matter tends to be very dry, but is critically important**
  - Highly regulated environment
  - Lives are at stake
- **Application (next semester) is *much* more engaging**
  - Goal for the future is to incorporate more real-world scenarios/applications
- **NCS as a discipline is very small**
  - ~400 people worldwide do what we do
  - Tight-knit community
  - All nuclear operations with significant quantities of fissile material require NCS engineers and there is currently a shortage
- **The pay is great (I know you all wanted to ask)**
- **Summer Internship posting should be up soon**
  - I will send word when it is